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(54) **A supervising loopback circuit and a transmitting and receiving circuit for an optical repeater system**

(57) A supervising loopback circuit for an optical transmission system is provided in an optical repeater comprising a pair of optical amplifiers 17, 18 for up and down sides inserted in an optical transmission link having up and down side optical fibre channels 12, 13 for a two way communication. The loopback circuit comprises a pair of optical couplers 19, 20 for tapping and coupling, so as to attenuate up and down side trunk channel signals superimposed with a supervisory signal, connected to said up and down side optical fibre channels, thereby returning up and down side signals inversely into said down and up side optical fibre channels so that said up and down side return signals are superimposed with said down and up side trunk channel signals, respectively, by way of both of said up and down side optical fibre channels. The supervisory signal may be frequency swept cw, short pulses or cw modulated by phase modulated by a pseudo-random code.

Fig. 9

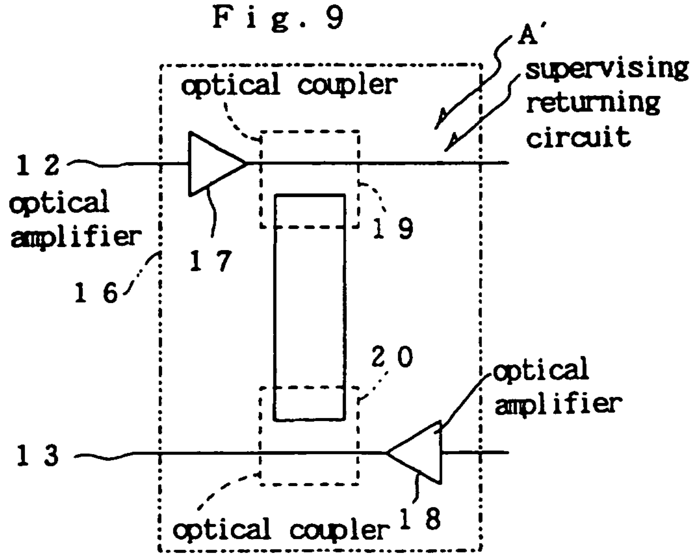

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Fig. 1

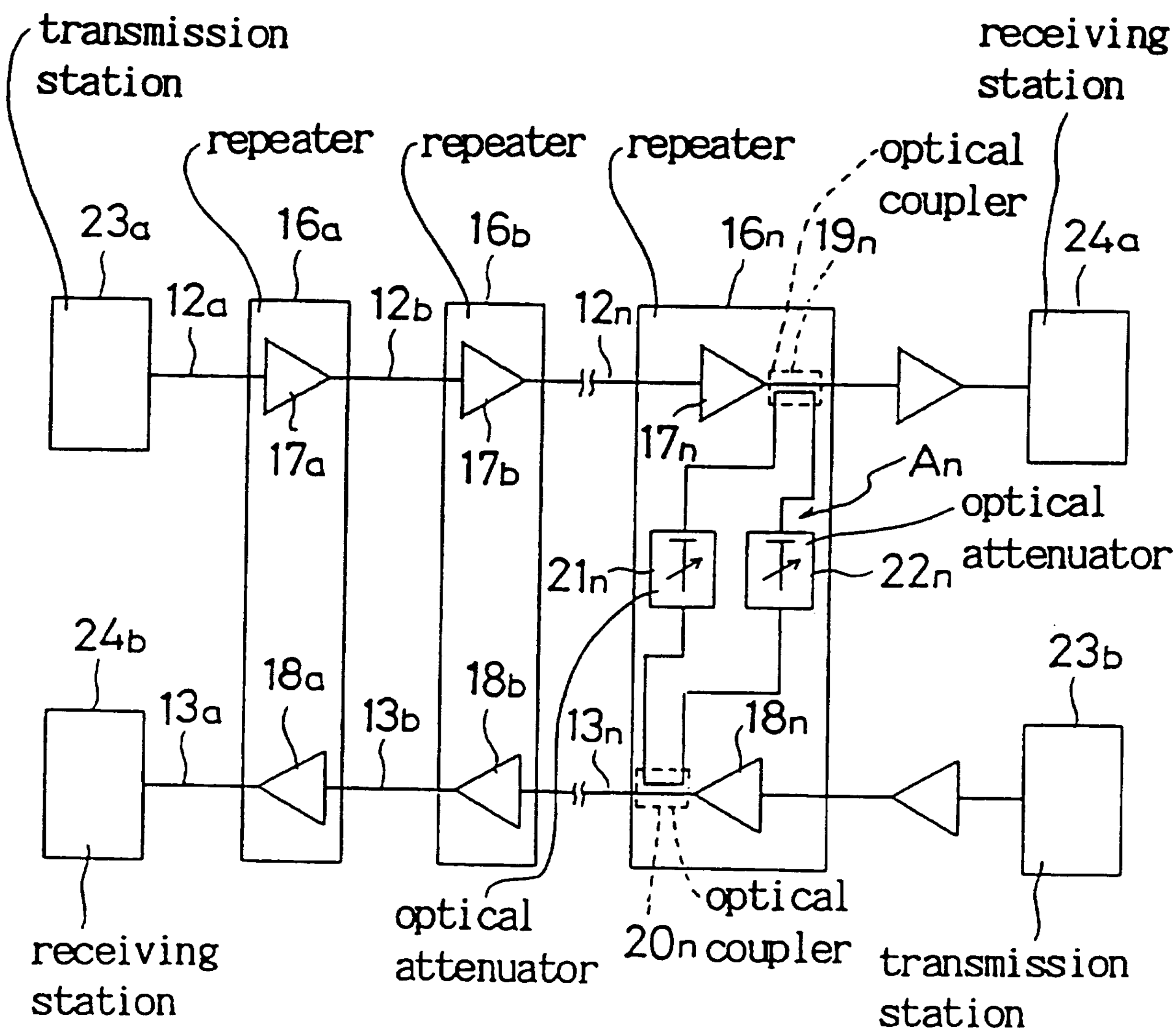

transmission station
repeater
repeater
repeater
optical coupler
receiving station
23a
16a
16b
16n
19n
24a
12a
12b
12n
17a
17b
17n
An
optical attenuator
21n
22n
24b
18a
18b
23b
13a
13b
13n
18n
optical attenuator
optical coupler
20n
receiving station
transmission station

Fig. 2

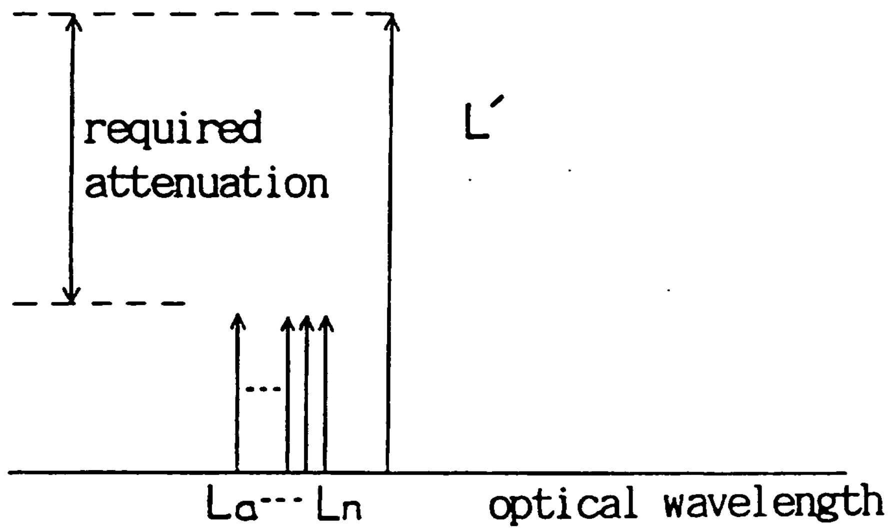

required
attenuation
L′
La··· Ln
optical wavelength

Fig. 3

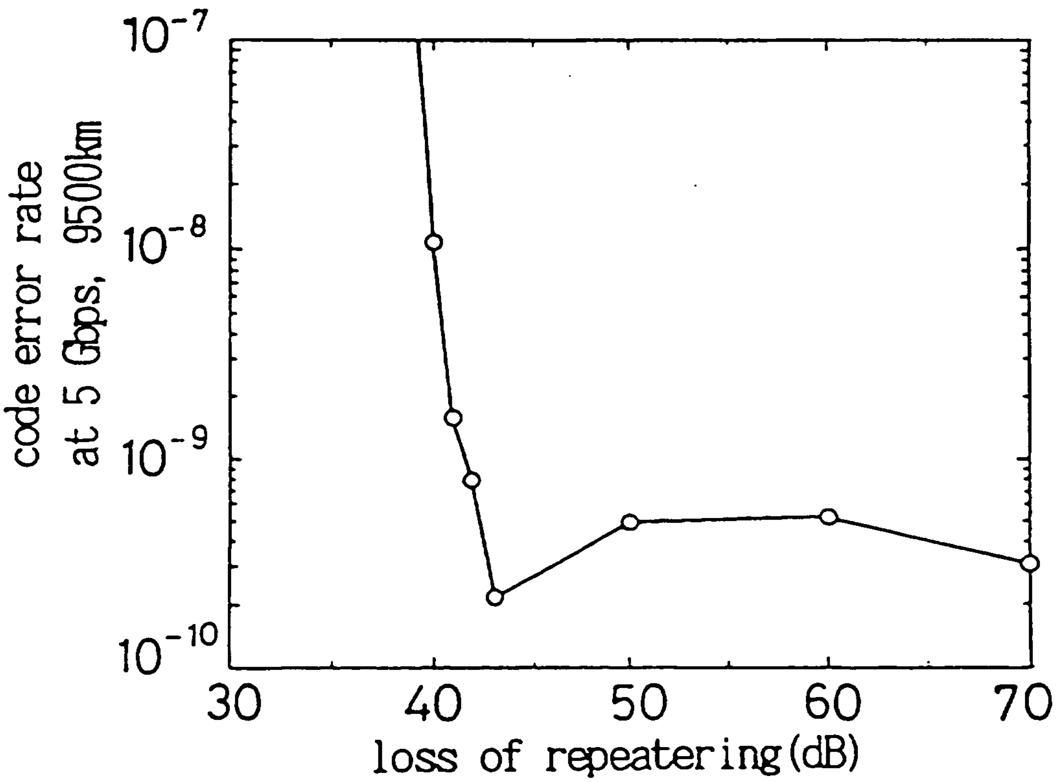

code error rate
at 5 Gbps, 9500km
10^{-7}
10^{-8}
10^{-9}
10^{-10}
30
40
50
60
70
loss of repeatering(dB)

Fig. 4

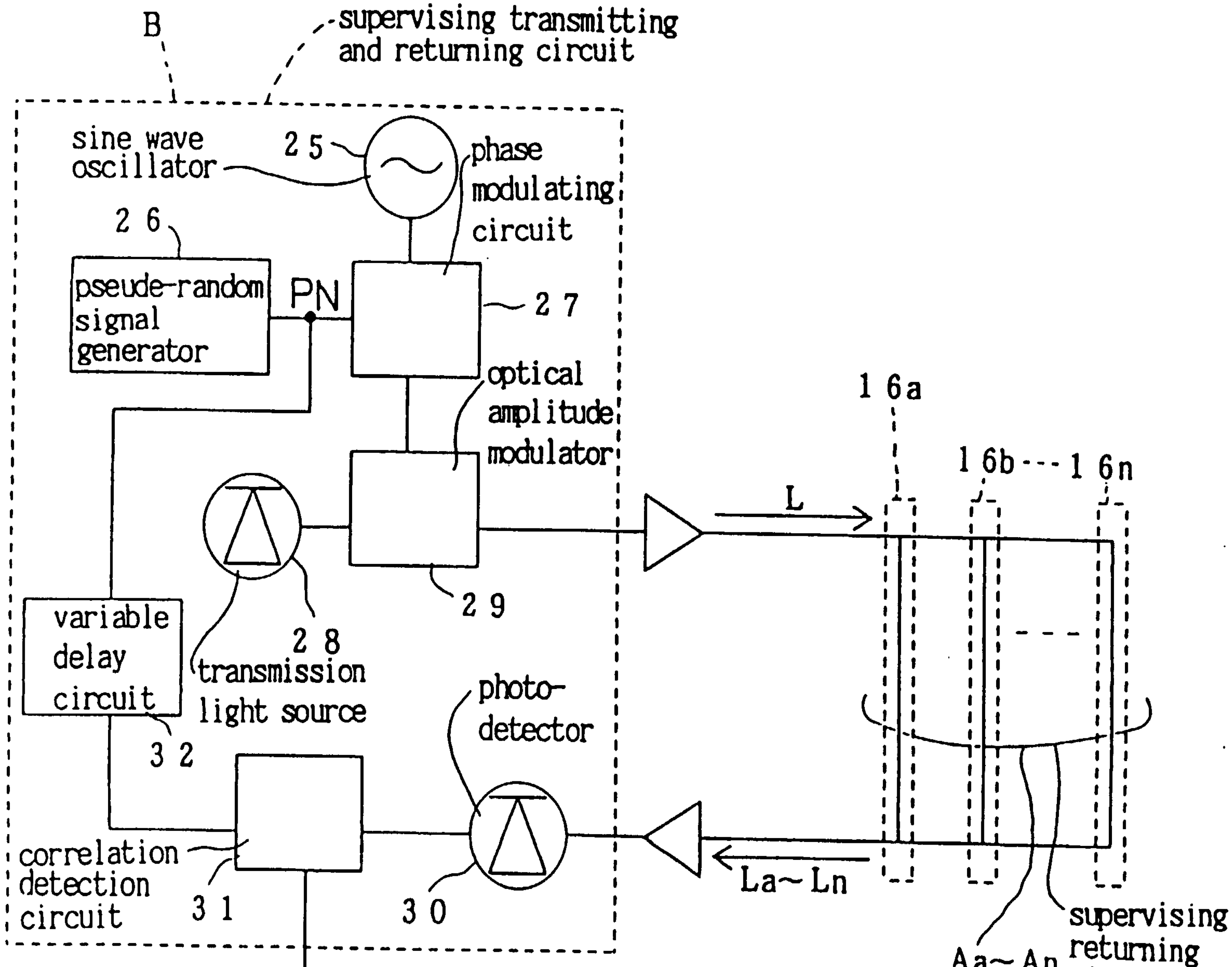

B
supervising transmitting
and returning circuit
sine wave
oscillator
25
phase
modulating
circuit
26
pseude-random
signal
generator
PN
27
optical
amplitude
modulator
29
28
transmission
light source
variable
delay
circuit
32
photo-
detector
correlation
detection
circuit
31
30
L
La~Ln
16a
16b---16n
Aa~An
supervising
returning
circuit

Fig. 5

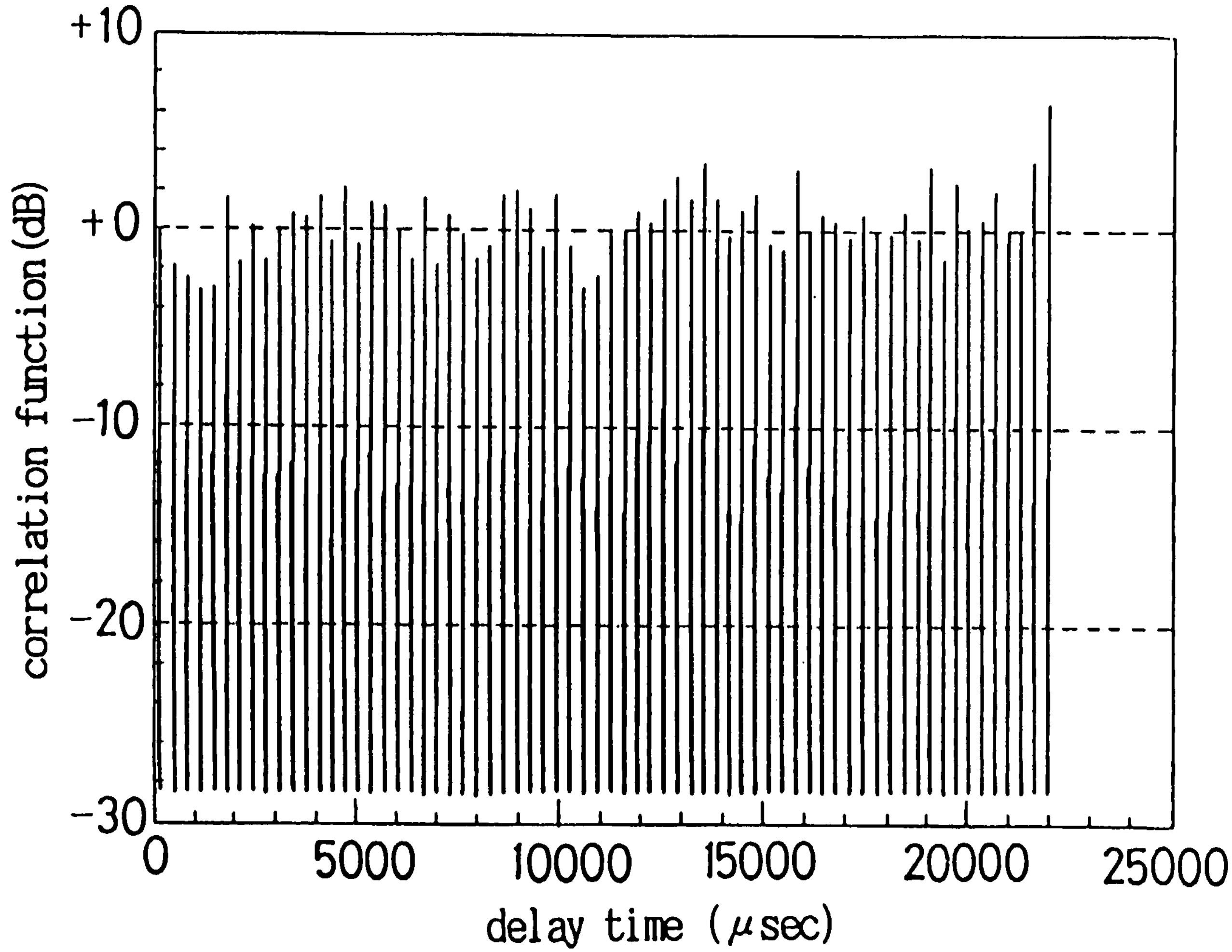

+10
+0
-10
-20
-30
0
5000
10000
15000
20000
25000
correlation function (dB)
delay time (μsec)

Fig. 6

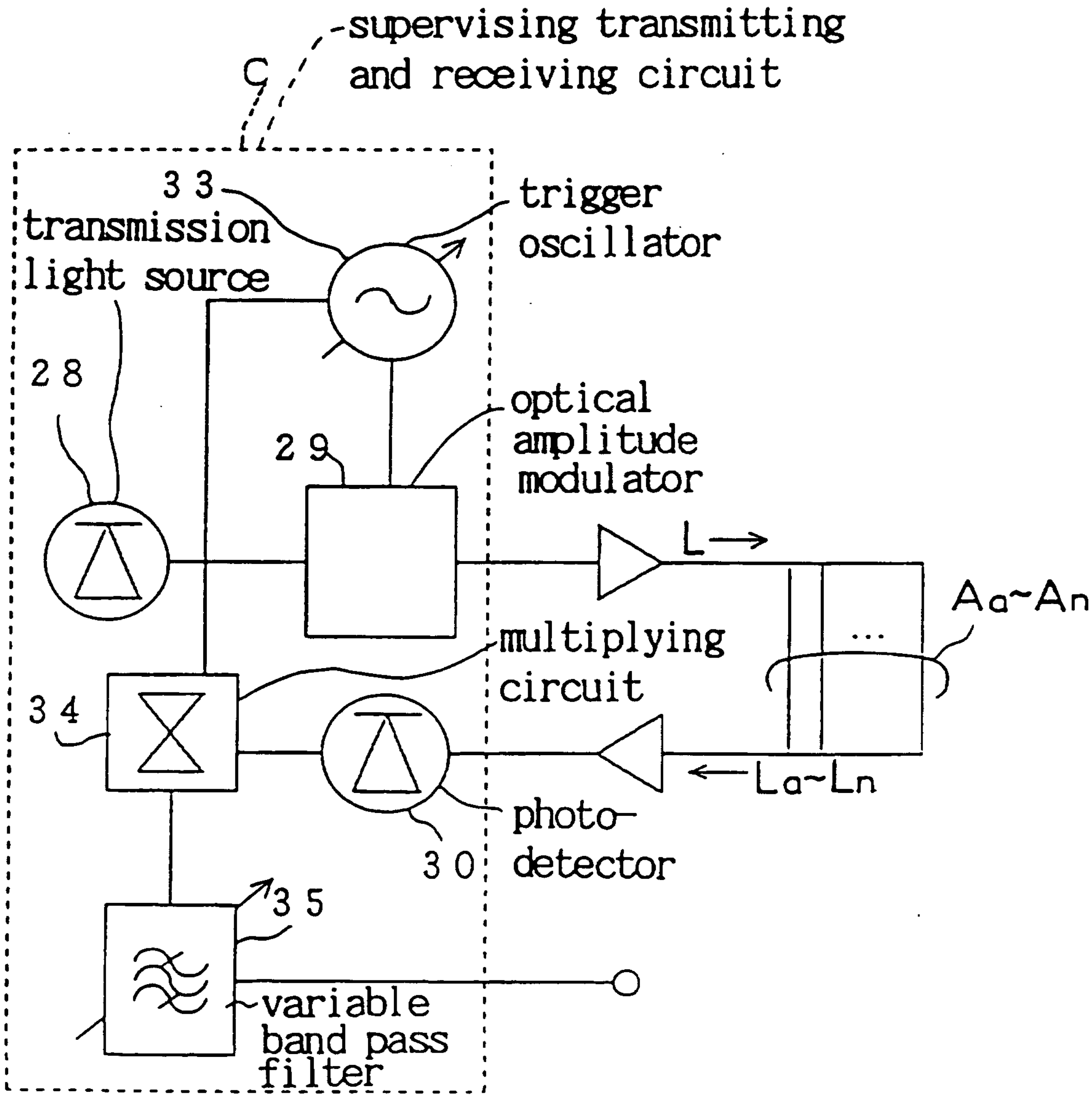

supervising transmitting
and receiving circuit
C
33
transmission
light source
trigger
oscillator
28
optical
amplitude
modulator
29
L→
Aa~An
...
multiplying
circuit
34
←La~Ln
photo-
detector
30
35
variable
band pass
filter

Fig. 7

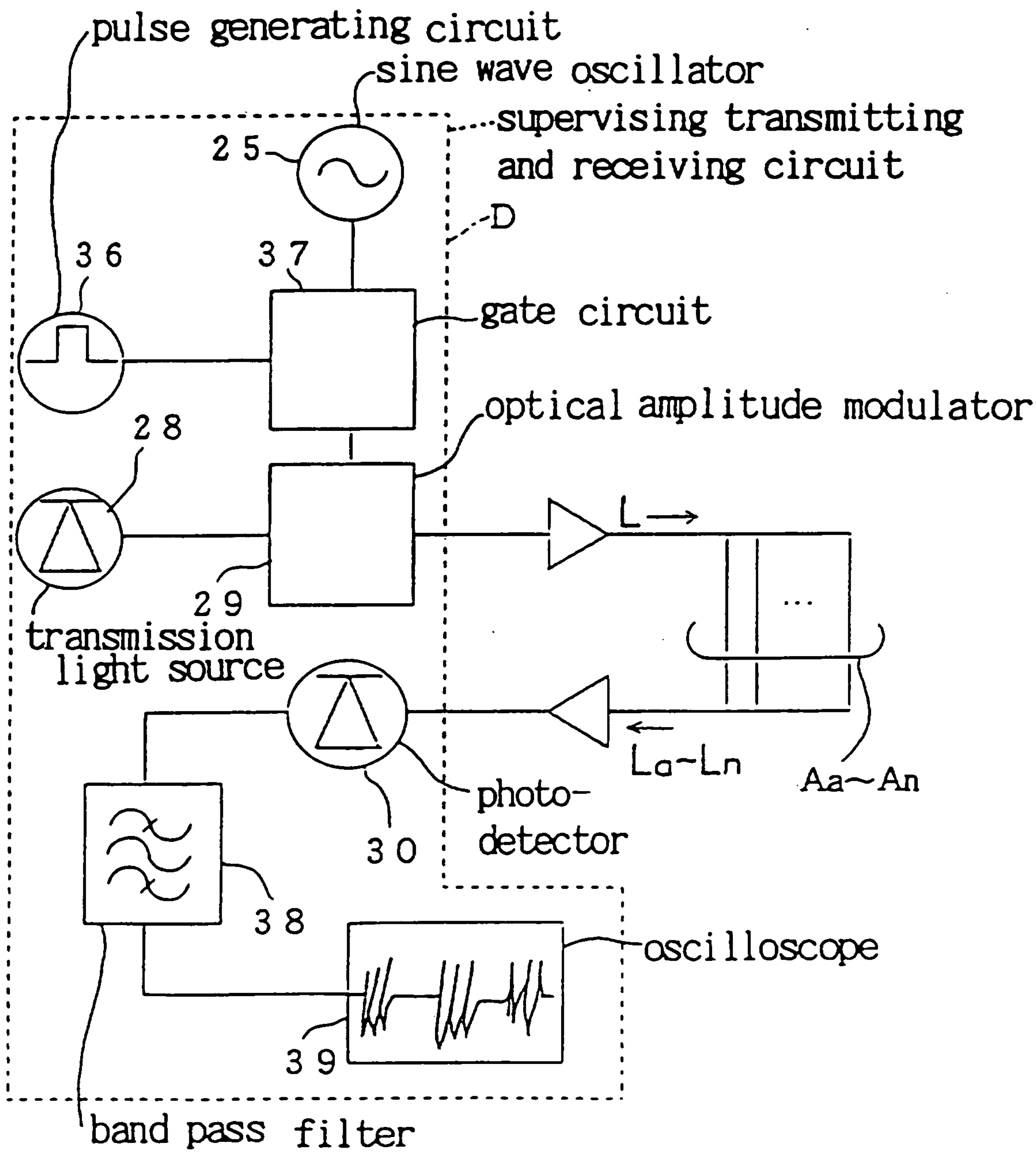

pulse generating circuit
sine wave oscillator
supervising transmitting and receiving circuit
25
D
36
37
gate circuit
optical amplitude modulator
28
L→
29
transmission light source
←
La~Ln
Aa~An
photo-detector
30
38
oscilloscope
39
band pass filter

Fig. 8

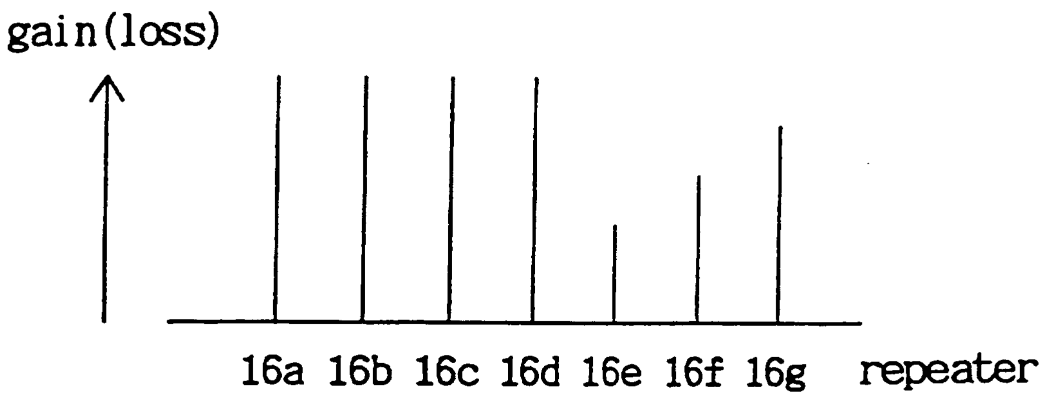

gain(loss)
16a 16b 16c 16d 16e 16f 16g
repeater

Fig. 9

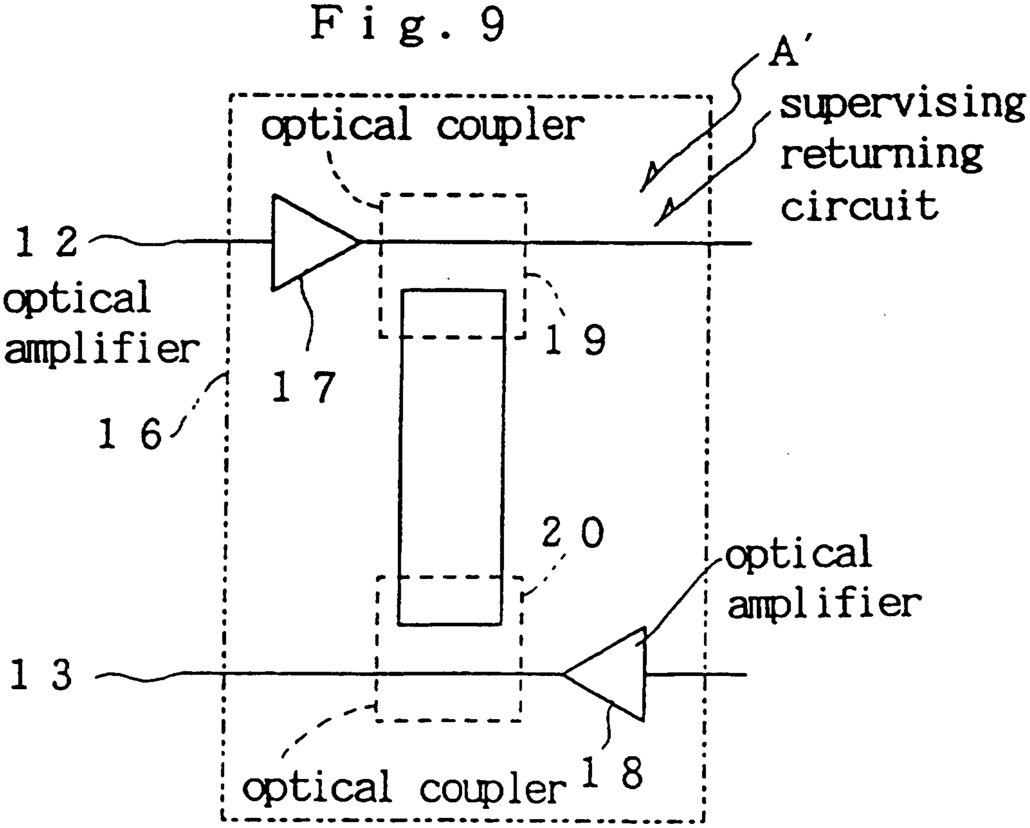

A′
supervising returning circuit
optical coupler
12
optical amplifier
17
19
16
20
optical amplifier
13
18
optical coupler

Fig. 10

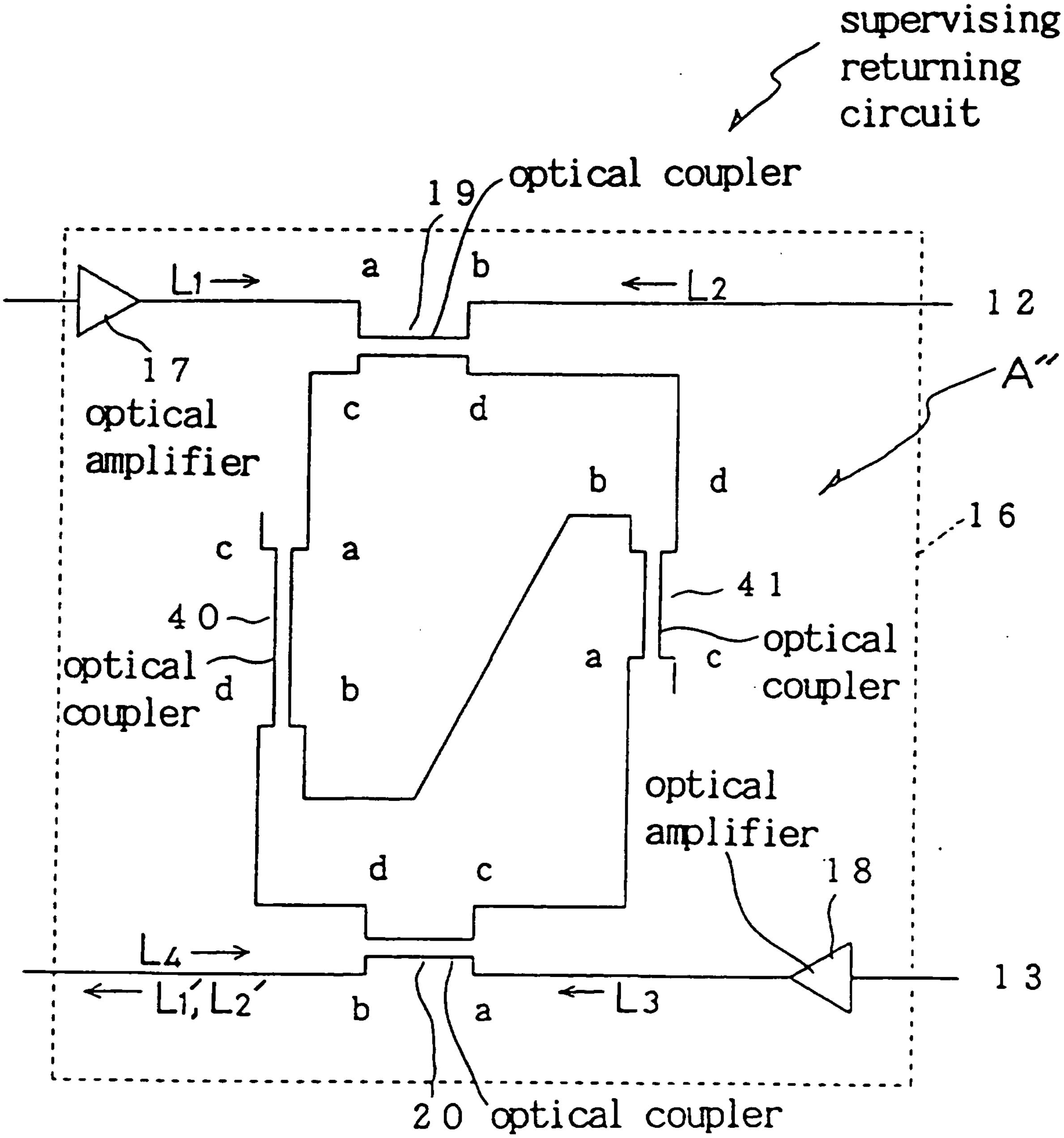
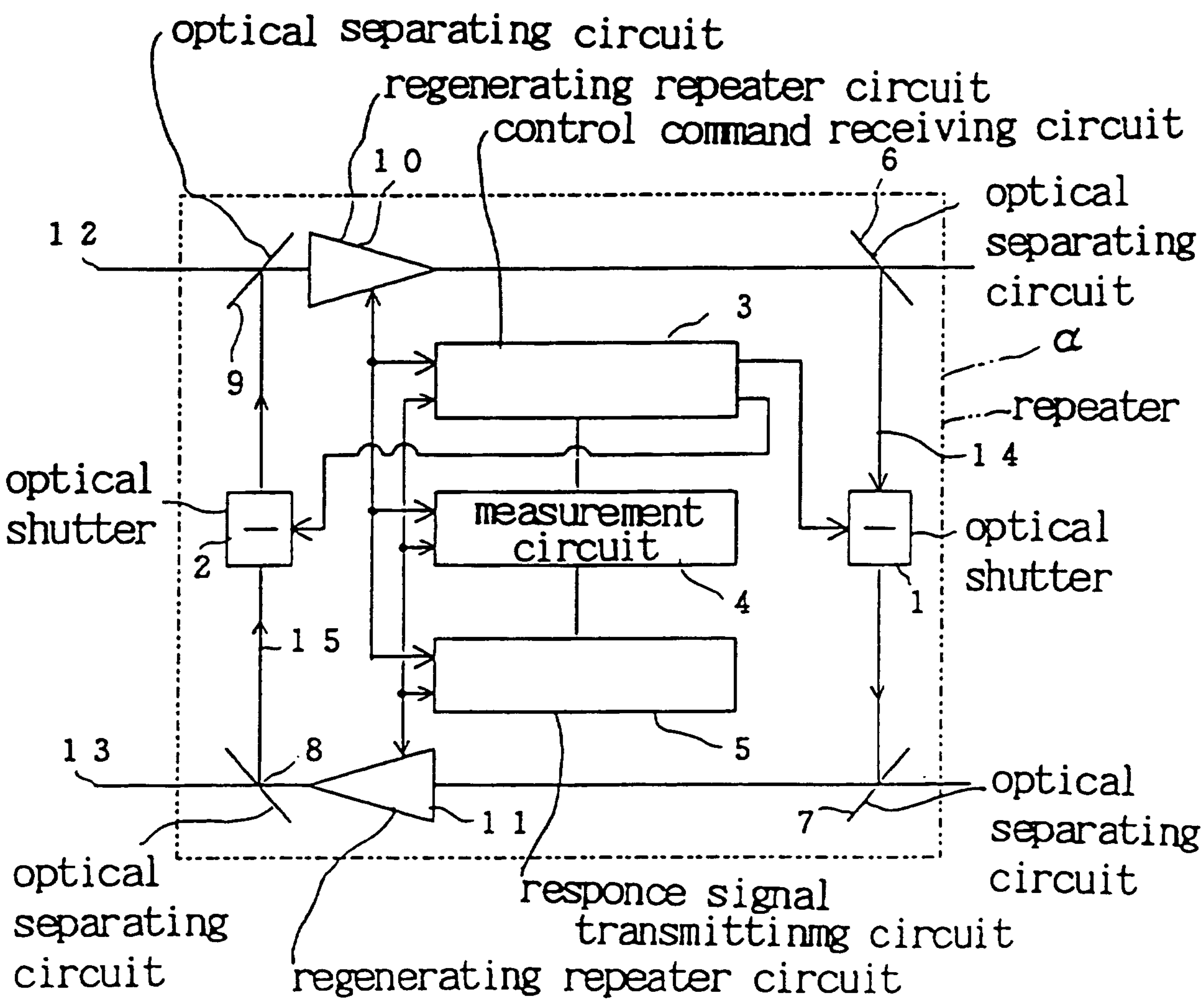

supervising returning circuit
19
optical coupler
a
b
L1
L2
12
17
optical amplifier
c
d
A''
b
d
16
c
a
41
40
optical coupler
a
c
optical coupler
d
b
optical amplifier
d
c
18
L4
13
L1', L2'
b
a
L3
20
optical coupler

Fig. 11


optical separating circuit
regenerating repeater circuit
control command receiving circuit
10
6
optical separating circuit
12
3
α
9
repeater
14
optical shutter
measurement circuit
optical shutter
2
4
1
15
5
13
8
optical separating circuit
11
7
optical separating circuit
responce signal transmittinmg circuit
circuit
regenerating repeater circuit

2294374

SPECIFICATION

Title of the invention

A supervising loopback circuit and a transmitting and receiving circuit for an optical repeater system

Background of the invention

This invention relates to a supervisory method for supervising repeaters and optical fibre's sections, inevitable for maintenance of a long-distance repeater system, such as an optical submarine cable system, which uses optical amplifiers, and to an optical circuit device directly used for the supervisory method.

Fig. 11 shows a supervisory loopback circuit of a conventional repeater system. The numerals 1, 2 are optical shutters. The numeral 3 is a control command receiving circuit. The numeral 4 is a measurement circuit 4. The numeral 5 is a response signal transmitting circuit. The numerals 6 to 9 are optical separating circuits. The numerals 10, 11 are regenerating repeater circuits. The numerals 12, 13 are up and down side optical fibre channels, respectively.

In such a conventional repeater system, a regenerating repeater system in which an optical digital signal is converted into an electric signal at each repeater to regenerate the optical signal has been used. In the example shown in Fig. 11,

one specific set of supervisory loopback circuits 14, 15, which are installed in each repeater a, is controlled to be open in response to a command from a terminal station, so that the optical signal regenerated at the repeater a is returned to the down side optical fibre channel 13. With receiving the signal at the receiving terminal station, the characteristics of the transmission from the transmitting station to the receiving station through the specific set of supervisory loopback circuits of the repeater a, is measured. A plurality of sets of the supervisory loopback circuits 14, 15 operate in turn, thereby enabling to supervise the entire system.

Since the supervisory system returns the trunk channel signal, such operation should run in case of not in services but out of services such as under its construction or at a time of occurrence of a fault. On the other hand, while in services, the system measures, within each of the repeaters a, operating conditions and a code error ratio of a light source arranged in each repeater a. The result of the measurements is superimposed on the trunk channel signal and sent through the trunk channel, so that the system can obtain a maintenance data, which is used for a prediction of the occurrence of a fault and a plan of repairs.

In the system using the optical amplifiers, as different from the regenerating repeater system, all of optical signals are amplified and repeatered through the optical repeaters as they are. Therefore, another supervisory system different from that of the regenerating repeater system can be introduced into the system using optical amplifiers, and, as a matter of course,

the optical loopback circuit can be applied for the optical repeater using the optical amplifier.

The conventional optical loopback system, however, needs the optical shutters 1, 2 for open and close of the supervisory loopback circuits 14, 15 and the control command receiving circuit 3 for remote controlling then from the terminal station as shown in Fig. 11, so that can not avoid its circuitry from being complicated. Particularly, in the optical repeater having a significantly simpler circuitry than that of the regenerating repeater system, the conventional supervisory circuit may be too large to be installed, and if installed, it may cause a problem in terms of cost-performance and high reliability of the system.

Summery of the invention

With the feature of the optical amplifying system, the invention is then provided as a supervisory method, a loopback circuit, and a transmitting and receiving circuit for an optical repeater system in which supervision of the system in-services can be performed with a very simple constitution thereof, which is avoiding complexity of circuits occurring to the conventional optical loopback system.

According to a first aspect of the invention, there is provided a supervisory method for an optical repeater system in which a plurality of optical repeaters, each of which includes a pair of up and down side repeating circuits using respective optical amplifiers, are inserted in an optical transmission link

having up and down side optical fibre channels for a two way communication, in order to supervise condition of the optical transmission link up to each of the optical repeaters, comprising the steps of providing a plurality of supervising loopback circuits for normally returning a part of a signal on the up and down side optical fibre channels, each of the supervising loopback circuits connecting outputs or inputs of the up and down side repeatering circuits with each other in all of the optical repeaters or some of the optical repeaters previously designated in the optical repeater system so as to give a proper attenuation to the signal, sending a supervisory signal from an up or down side transmission station to the optical transmission link, receiving a plurality of the supervisory signals returned through the supervising loopback circuits in all of the optical repeaters or some of the optical repeaters previously designated at a receiving station, separating and detecting the supervisory signals for respective of the optical repeaters.

For the purposes of this specification the supervisory method may includes a supervising loopback circuit in each repeater giving its attenuation larger than an attenuation determined by adding 15 dB to 10 Log (N) dB, where the number of the optical repeaters of the optical repeater system per channel is N. The up or down transmission station may send a pseudo-random signal of an m-sequence, having a repeating period longer than a going and round trip time of the optical repeater system, a reference signal of a sine wave or the like, generated so that the frequency of the reference signal is triggered along time, or a pulse signal having a pulse width narrower than a time of

an optical signal traveling through the spacing between said repeaters, as the supervisory signal. In the case of the pseudo-random signal, the receiving station may perform a correlative detection with the transmitted supervisory signal. In the case of the reference signal, the receiving station mixes the reference signal with a plurality of returned supervisory signals to produce a beat, whose frequency is varied in accordance with a going and returning delay time of said respective repeaters, to detect a signal returned by a predetermined repeater. In the case of the pulse signal, the receiving station distinguishes the returned supervisory signals in accordance with differences among going and round trip times. The supervisory signal may be previously modified by a carrier having an adequately low speed with respect to a trunk channel signal in the case of the reference signal and the pulse signal, and transmitted through an amplitude modulation of the trunk channel signal with a carrier containing a spectrum of the supervisory signal.

According to another aspect of the invention there is provided a supervising loopback circuit for an optical repeater system, provided in an optical repeater constituted of a pair of optical amplifiers for up and down sides inserted in an optical transmission link having up and down side optical fibre channels for a two way communication, characterized in that a pair of optical couplers for tapping and coupling, so as to attenuate up and down side trunk channel signals superimposed with a supervisory signal, are connected to the up and down side optical fibre channels, thereby returning up and down side returned signals inversely into the down and up side optical fibre channels so

that the up and down side returned signals are superimposed with the down and up side trunk channel signals, respectively, by way of both of the up and down side optical fibre channels.

The supervising loopback circuit may further include a pair of optical attenuators arranged between said up and down side optical fibre channels. The supervising loopback circuit may further include a pair of optical couplers, arranged in opposition to each other between said up and down side optical fibre channels so as to attenuate an optical signal passing therethough, in which the up and down side trunk channel signals can be superimposed with a modulated supervisory signal and backscatter light to transmit through the optical fibre channels.

According to a yet another aspect of the invention there is provided a supervising transmitting and receiving circuit for an optical repeater system comprising of a sine wave oscillator for generating a carrier, a pseudo-random signal generator for generating a PN signal of an m-sequence, a phase modulation circuit for phase modulation of the carrier with the PN signal, the phase modulation circuit outputting a phase modulated signal, a transmission light source for transmitting a communication signal as a trunk channel signal, an optical amplitude modulator for an amplitude modulation of the trunk channel signal with the phase modulated signal to produce a supervisory signal and sending the supervisory signal to an up side optical fibre channel, a photo-detector for converting a group of returned optical signals into an electric signal, the returned optical signals returned by a group of supervising loopback circuits through a down side optical fibre channel, the super-

vising loopback circuits arranged in parallel so as to form a multi-stage between the up and down side optical fibre channels, a variable delay circuit for making the PN signal to be delayed for a predetermined time and outputting a delayed PN signal, and a correlative detection circuit for tuning the electric signal with the delayed PN signal.

According to a further aspect of the invention there is provided a supervising transmitting and receiving circuit for an optical repeater system comprising of a trigger oscillator for generating a reference signal of a sine wave, or the like, the reference signal being generated so that the frequency of the reference signal is triggered along time, a transmission light source for transmitting a communication signal as a trunk channel signal, an optical amplitude modulator for an amplitude modulation of the trunk channel signal with the reference signal to produce a supervisory signal and sending the supervisory signal to an up side optical fibre channel, a photo-detector for converting a returned optical signal into an electric signal, the returned optical signal returned by a group of supervising loopback circuits through a down side optical fibre channel, the supervising loopback circuits arranged in parallel so as to form a multi-stage between the up side optical fibre channel and the down side optical fibre channel, a multiplying circuit for generating a signal of a beat frequency by multiplying the electric signal by the reference signal, and a variable band pass filter circuit for extracting the electric signal by turning with the signal of the beat frequency.

According to a yet further aspect of the invention there is

provided a supervising transmitting and receiving circuit for an optical repeater system comprising of a sine wave oscillator for producing a carrier, a pulse generating circuit for generating a pulse signal, which has a pulse width narrower than a time of an optical signal traveling through the spacing between the optical repeaters, and has a period longer than a going and returning delay time of an optical signal traveling the overall length of the optical repeater system, a gate circuit for modulating the amplitude of the carrier by the pulse signal and outputting a pulse modulated signal, a transmission light source for transmitting a communication signal as a trunk channel signal, an optical amplitude modulator for amplitude-modulating the trunk channel signal with the pulse modulated signal to produce a supervisory signal and sending the supervisory signal to an up side optical fibre channel, a photo-detector for converting a returned optical signal into an electric signal, the returned optical signal returned by a group of supervising loopback circuits through a down side optical fibre channel, the supervising loopback circuits arranged in parallel so as to form a multi-stage between the up and down side optical fibre channels, a band pass filter for eliminating noise of the electric signal, and an oscilloscope for displaying the electric signal passed through the band pass filter.

In the invention, the conventional opening and closing control of the supervising loopback circuit from the shore terminal station is unnecessary, and a supervising loopback circuit, normally conducting, giving a predetermined optical attenuation to an optical signal passing therethrough, can be

installed in each repeater. The supervising loopback circuit thus constructed makes a control receiving circuit and an optical shutter unnecessary and allows its circuitry to be simple. The predetermined optical loss is an attenuation such that a plurality of returned signals does not affect the trunk channel signal.

The receiving station receives a plurality of supervisory signals returned from respective repeaters at the same time, and separates and detects a returned signal from a predetermined repeater through various methods utilizing differences of propagation time that a signal propagates from the transmitting station to the receiving station through those repeaters.

Following is a description by way of example only and with reference to the accompanying drawings of methods of carrying the invention into effect:-

Brief description of the drawings

Fig. 1 is a schematic diagram of an optical repeater system according to Example 1 of the invention;

Fig. 2 is a spectrum diagram of the signal transmitted through an optical fibre channel of Example 1;

Fig. 3 is a graph showing a relation between an attenuation and a code error rate as a result of measurement of Example 1;

Fig. 4 is a schematic diagram of a supervising transmitting and receiving circuit according to Example 2;

Fig. 5 is a graph showing a result of measurement of gain

or loss of returned signals from respective repeaters;

Fig. 6 is a schematic diagram of a supervising transmitting and receiving circuit according to Example 3;

Fig. 7 is a schematic diagram of a supervising transmitting and receiving circuit according to Example 4;

Fig. 8 is a schematic diagram showing a pattern of gain or loss of signals returned by respective repeaters according to Examples 2 to 4;

Fig. 9 is a schematic diagram of a supervising loopback circuit according to Example 5;

Fig. 10 is a schematic diagram of a supervising loopback circuit according to Example 6; and

Fig. 11 is a schematic diagram of a supervising loopback circuit of a conventional optical repeater system.

Detailed description of the invention

Example 1

Referring to the drawings, Example 1 will be described in detail. Fig. 1 is a diagram showing an optical repeater system including supervising loopback circuits according to Example 1. In Fig. 1, the numerals 12a to 12n and 13a to 13n are up and down side optical fibre channels of an optical transmission link, respectively. The numerals 16a to 16n are optical repeaters. The numerals 17a to 17n and 18a to 18n are up side and down side optical amplifiers installed in the optical repeaters

16a to 16n. The numerals 19a to 19n and 20a to 20n are optical couplers for tapping and coupling an optical signal, arranged at outputs of the optical amplifiers 17a to 17n and 18a to 18n, respectively. The numerals 21a to 21n and 22a to 22n are optical attenuators giving a predetermined optical loss to the signal passing therethrough. The numerals Aa to An are supervising loopback circuits.

In Fig. 1, although only the optical repeater 16n is depicted as larger than the other repeaters, all optical repeaters 16a to 16n have an almost same constitution. The numerals 23a, 23b are transmission stations for transmitting a communication signal superimposed with a supervisory signal, connected to up and down side optical fibre channels of the optical transmission link, respectively. The numerals 24a, 24b are receiving stations for receiving communication signals returned at respective optical repeaters 16a to 16n and for then separating and detecting the supervisory signal for respective optical repeaters 16a to 16n.

In operation, as shown in Fig. 1, a supervisory signal is superimposed with a communication signal, or a trunk channel signal, through an amplitude-modulation of a small modulation Index, and is transmitted to the up side optical fibre channel 12a. The communication signal is amplified by the optical amplifiers 17a to 17n of respective repeaters 16a to 16n and is repeatered. At respective repeaters 16a to 16n, the communication signal is tapped by the optical couplers 19a to 19n, respectively, and tapped signals are supplied to the outputs on the down side of respective repeaters 16a to 16n by the optical

couplers 20a to 20n, through the optical attenuators 22a to 22n, respectively. The signal transmitted from the transmission station 23b on the down side is also returned to the up side optical fibre channels 12a to 12n through the optical couplers 20a to 20n, the optical attenuators 21a to 21n, and the optical couplers 19a to 19n.

Therefore, for example, whenever a communication signal L' is repeatered at all of the optical repeaters 16a to 16n on the down side optical fibre channel, the communication signal L' is superimposed with communication signals La to Ln returned from the up side optical fibre channel at all of the optical repeaters 16a to 16n. As shown in Fig. 2, the spectrum of the down side optical fibre channel is composed of the down side communication signal L' and a plurality of returned up side communication signals La to Ln. Although, to show clearly, returned communication signals La to Ln are depicted so as to be next to each other on the axis of the wavelength, those signals have the same wavelength as a matter of fact. The returned communication signals La to Ln have to be attenuated enough so as not to affect the down side communication signal L' as shown in Fig. 2. In other words, it is an important factor for the invention to design installation of the supervising loopback circuits Aa to An normally conducting, and amount of attenuation of those circuits.

Fig. 3 shows a result of the measurement of impairment of a communication signal against the amount of attenuation. As apparent from this result, in consideration with an optical repeater system having 300 repeaters, at least it is necessary

to set the power of the returned communication signal per one portion equal to or less than 40 dB with respect to the original power of the communication signal. Since the returned signals La to Ln are added one by one, the attenuation may not be restricted if the number of the optical repeaters is small. As drawn from Fig. 3, since the system having 300 repeaters has an accumulated effect of 25 dB, where in the case that the number of the optical repeaters is arbitrary N, the minimum demanded attenuation is set to 15 dB per repeater plus 10 Log (N) dB. According to the constitution thus designed, the system can avoid that the character of the communication signal is impaired due to the installation of the supervising loopback circuits Aa to An normally conducting.

In Fig. 1, for example, in the optical repeater system including 300 repeaters, the receiving station receives returning communication signals from the optical repeaters of 300 at the same time. Therefore, it is important how to separate the returned communication signals at the receiving station. Hereinafter, the constitution of the supervisory signal and separating means provided in a receiving circuit will be described.

Example 2

Referring to the drawings, Example 2 according to the invention will be described in detail. Fig. 4 is a diagram showing a constitution of the supervising transmitting and receiving circuit. In the drawing, the numeral B is a supervising trans-

mitting and receiving circuit of Example 2. The numeral 25 is a sine wave oscillator operating with a low speed with respect to the communication signal. The numeral 26 is a pseudo-random signal generator operating with a lower speed than that of the sine wave oscillator 25. The numeral 27 is a phase modulating circuit. The numeral 28 is a transmission light source for transmitting the communication signal. The numeral 29 is an optical amplitude modulator. The numerals Aa to An are a plurality of the supervising loopback circuits of Example 1. The numeral 30 is a photo-detector of a receiving circuit. The numeral 31 is a correlation detection circuit. The numeral 31 is a variable delay circuit.

In operation, the PN signal of the m-sequence modulates the phase of a carrier, which is produced by the sine wave oscillator 25. The modulated signal modulates the amplitude of the trunk channel signal sent from the transmission light source 28 by the optical amplitude modulator 29. One hand, the signal returned by the supervising loopback circuits Aa to An are converted into an electric signal by the photo-detector 30, and then, the electric signal is supplied to the correlation detection circuit 31.

On the other hand, the PN signal is introduced to the correlative detection circuit 31 with a predetermined delay time given by the variable delay circuit 32. Since times needed for returning at respective repeaters 16a to 16n are different from each other, to adjust the delay time provides a correlation with one of returning communication signals La to Ln from respective of the optical repeaters 16a to 16n. To change the delay time

provides a correlation with a returning communication signal from another optical repeater. By this operation, the gains and losses of the signal going to and returning from the respective repeaters are measured. An example of a result of the measurement according to Example 2 is shown in Fig. 5. The result is based on the following conditions for measurement.

Carrier Frequency: 4.5 MHz
PN bit rate: 100 kbps
Correlative Detection Circuit 31: In Phase Adjuster
Averaging time : 10 times (14 sec)
System Length : 2,250 Km (Spacing 33 Km)
PN = 17

Example 3

Referring to Fig. 6, Example 3 will be described in detail. Fig. 6 is a diagram showing a constitution of an example of the supervising transmitting and receiving circuit. In Fig. 6, the numeral C is the supervising transmitting and receiving circuit of Example 3. The numeral 33 is a frequence sweep oscillator. The numeral 34 is a multiplying circuit. The numeral 35 is a variable band pass filter. The elements same to those of Example 2 in Fig. 4 have the identical reference numbers, respectively.

In operation the frequence sweep oscillator 33 generates ramp frequence signal with a constant speed.The lamp signal is super-

imposed on the communication signal from the transmitting light source 28 by an amplitude modulation at the optical amplitude modulator 29 and is transmitted to the channel. A plurality of returned communication signals La to Ln are converted to an electric signal, and then, the electric signal is multiplied by the output of the frequence sweep oscillator 33 to generate a difference, or a beat, frequency. Since the difference frequency is determined by the product of the ramp speed of the frequence sweep oscillator 33 and the delay time going to and returning from the respective repeaters 16a to 16n, all of the optical repeaters 16a to 16n has the own value of the difference frequency, respectively, which is different from another else. Therefore, turning the variable band pass filter 35 at a predetermined frequency allows the expected one of returned communication signals La to Ln from the respective repeaters 16a to 16n to be detected.

Example 4

Referring to Fig. 7, Example 4 will be described in detail. Fig. 7 is a diagram showing a constitution of an example of the supervising transmitting and receiving circuit. In Fig. 7, the numeral D is the supervising transmitting and receiving circuit of Example 4. The numeral 36 is a pulse generating circuit for generating a pulse having its width shorter than a time that an optical signal traveling the spacing between the optical repeaters 16a to 16n of the repeater system, and having a longer

period than a going and returning delay time that an optical signal takes to travel the overall length of the system. The numeral 37 is a gate circuit. The numeral 38 is a band pass filter tuned to the sine wave oscillating circuit 25. The numeral 39 is an oscilloscope. The elements same to those of Example 2 in Fig. 4 have the identical reference numbers, respectively.

In operation, the gate circuit 37 modulates the amplitude of the carrier from the sine wave oscillator 25 by a pulse signal from the pulse generator 36 into a pulse shape, and then the pulse shaped signal modulates the amplitude of the communication signal at the optical amplitude modulator 29 to transmit the modulated communication signal to the trunk channel. A plurality of the returned communication signals La to Ln are converted into an electric signal, and then the electric signal passes the band pass filter 38 to reduce the noise of the electric signal. Since the returned communication signals La to Ln have different returning propagation times, respectively, pulse signals are detected and displayed on a time sequence.

As described above, supervising loopback circuits Aa to An normally conducting are installed in the respective optical repeaters 16a to 16n, and separation and detection of the signal is performed at the supervising transmitting and receiving circuits B, C, and D. Therefore, the gains and losses of a signal going to and returning from the respective repeaters 16a to 16n are obtained in turn.

Fig. 8 is a schematic diagram showing a pattern of gains and losses of signals returned by respective repeaters as of

supervising operation according to Examples 2 to 4. In this pattern, signals up to the optical repeater 16d indicate predetermined gains, respectively, but the signal of the optical repeater 16e indicates a reduced gain. This brings a presumption that an impairment occurs between the optical repeaters 16d, 16e.

Although the examples in which the supervising loopback circuits Aa to An of the optical signal are installed between the outputs of the up and down sides of the optical repeaters 16a to 16n are described above, such supervising loopback circuits can be installed between the inputs, and the same effect can be obtained. Installing the supervising loopback circuits Aa to An between the input and output of repeaters is also possible.

Moreover, although the examples in which the supervising loopback circuits Aa to An are installed in all of the optical repeaters 16a to 16n are described above, such supervising loopback circuits can be installed intermittently or on the up and down sides alternatively, and the same effect can be obtained. In this case, the losses of the supervising loopback circuits Aa to An is reduced in proportion to a ratio of the intermittent installing as a matter of course. Although the examples in which the supervising loopback circuits Aa to An give a uniform loss to the signal are described above, the system can be designed so that as far as the loss is in a range satisfying the minimum required attenuation, for example, the losses of sections respectively composed of a plurality of repeaters are different from another else.

Example 5

Referring to Fig. 9, Example 5 will be described in detail. Fig. 9 is a diagram showing a constitution of an example of the supervising transmitting and receiving circuit. In Fig. 9, the numeral A' is a supervising transmitting and receiving circuit. The numerals 12, 13 are up and down side optical fibre channels. The numeral 16 is an optical repeater. The numerals 17, 18 are optical amplifiers. The numerals 19, 20 are optical couplers.

Although the supervising loopback circuits Aa to An of Example 1 use the optical attenuators 21a to 22n to give an attenuation to the signal, the supervising loopback circuits of Example 5 are constructed as shown in Fig. 9, so that arranging the tapping ratio of the optical couplers 19, 20 to be large brings a large attenuation at a time of tapping and coupling, thereby giving a predetermined loss to the signal.

Example 6

Referring to Fig. 10, Example 6 will be described in detail. Fig. 10 is a diagram showing a constitution of an example of the supervising transmitting and receiving circuit. In Fig. 10, the numeral A" is a supervising transmitting and receiving circuit. The numerals 12, 13 are up and down side optical fibre channels. The numeral 16 is an optical repeater. The numerals

17. 18 are optical amplifiers. The numerals 19, 20, 40 and 41 are optical couplers.

The supervising transmitting and receiving circuit A" is constituted of a circuit for transferring from the up side optical fibre channel for the up side trunk channel signal L1 and backscatter light L2 to the down side optical fibre channel or the opposite, and includes the optical couplers 19, 20 for tapping and coupling and intermediate optical couplers 40, 41.

In thus constructed supervising transmitting and receiving circuit A", the up side trunk channel signal L1 passes from point a to point d of the optical coupler 19 for tapping and coupling, branches off at the intermediate optical coupler 41 so as to pass from point d to point a of the intermediate optical coupler 41, and passes from point c to point b of the optical coupler 20 for tapping and coupling. The up side trunk signal L1 is attenuated by the up side supervising loopback circuit, thereby becoming a predetermined returned trunk channel signal L1', which is integrated to and superimposed with the down side trunk channel signal L3.

On the other hand, the backscatter light, having a 20 dB loss with respect to the up side trunk channel signal L1, passes from point b to point c of the optical coupler 19 for tapping and coupling, passes from point a to point b of the intermediate optical coupler 40, passes from point b to point a of the intermediate optical coupler 41, and passes from point c to point b of the optical coupler 20 for tapping and coupling. The backscatter light L2 is attenuated by an up side fault finding returning circuit thus constructed, thereby becoming a predeter-

mined returned backscatter light L2', which is integrated to and superimposed with the down side trunk channel signal L3.

At that time, it is desirable to design so that the optical couplers 19, 20 for tapping and coupling having those attenuation ratio, for example 10 dB, and the intermediate optical couplers 40, 41 having those attenuation ratio, for example 30 dB are arranged, and the returned trunk channel signal L1' and the returned backscatter light L2 are attenuated to, for example, 40 dB, respectively.

As described above, the invention can supervise the occurrence of impairment of the system in services with a very simple constitution in comparison with the prior art. Therefore, the invention realizes highly cost performance and highly reliable supervisory system.

CLAIMS

1. A supervising loopback circuit for an optical repeater system, provided in an optical repeater constituted of a pair of optical amplifiers for up and down sides inserted in an optical transmission link having up and down side optical fibre channels for a two way communication, characterised in that a pair of optical couplers for tapping and coupling, so as to attenuate up and down side trunk channel signals superimposed with a supervisory signal, are connected to said up and down side optical fibre channels, thereby returning up and down side returned signals inversely into said down and up side optical fibre channels so that said up and down side returned signals are superimposed with said down and up side trunk channel signals, respectively, by way of both of said up and down side optical fibre channels.

2. A supervising transmitting and receiving circuit for an optical repeater system comprising of:

a sine wave oscillator for generating a carrier;

a pseudo-random signal generator for generating a PN signal of an m-sequence;

a phase modulation circuit for phase modulation of said carrier with said PN signal, said phase modulation circuit outputting a phase modulated signal;

a transmission light source for transmitting a communication signal as a trunk channel signal;

an optical amplitude modulator for amplitude modulation of said trunk channel signal with said phase modulated signal to produce a supervisory signal and

sending said supervisory signal to an up side optical fibre channel;

a photo-detector for converting a group of returned optical signals into an electric signal, said returned optical signals returned by a group of supervising loopback circuits through a down side optical fibre channel, said supervising loopback circuits arranged in parallel so as to form a multi-stage between said up and down side optical fibre channels;

a variable delay circuit for making said PN signal to be delayed for a predetermined time and outputting a delayed PN signal; and

a correlative detection circuit for tuning said electric signal with said delayed PN signal.

3. A supervising transmitting and receiving circuit for an optical repeater system comprising of:

a frequency sweep oscillator for generating a reference signal of a sine wave, or the like, said reference signal generated so that the frequency thereof is sweeped along time;

a transmission light source for transmitting a communication signal as a trunk channel signal;

an optical amplitude modulator for an amplitude modulation of said trunk channel signal with said reference signal to produce a supervisory signal and sending said supervisory signal to an up side optical fibre channel;

a photo-detector for converting a plurality of returned optical signals into an electric signal, said returned optical signals returned by a group of supervising loopback circuits through a down side optical fibre channel, said supervising loopback

circuits arranged in parallel so as to form a multi-stage between said up and down side optical fibre channels;

a multiplying circuit for generating a signal of a beat frequency by multiplying said electric signal by said reference signal; and

a variable band pass filter circuit for extracting said electric signal by turning with said signal of said beat frequency.

4. A supervising transmitting and receiving circuit for an optical repeater system comprising of:

a sine wave oscillator for producing a carrier;

a pulse generating circuit for generating a pulse signal, which has a width narrower than a time of an optical signal travelling through the spacing between said repeaters, and has a period longer than a going and returning delay time of an optical signal travelling the overall length of said optical repeater system;

a gate circuit for modulating the amplitude of said carrier by said pulse signal and outputting a pulse modulated signal; a transmission light source for transmitting a communication signal as a trunk channel signal;

an optical amplitude modulator for amplitude-modulating said trunk channel signal with said pulse modulated signal to produce a supervisory signal and sending said supervisory signal to an up side optical fibre channel;

a photo-detector for converting a returned optical signal into an electric signal, said returned optical signal returned by a group of supervising loopback circuits through a down side optical fibre channel, said supervising loopback circuits arranged in parallel so as to form a multi-stage between said up and down side optical

fibre channels;

a band pass filter for eliminating noise of said electric signal; and

an oscilloscope for displaying said electric signal passed through said band pass filter.

5. A supervising loopback circuit for an optical repeater system, provided in an optical repeater constituted of a pair of optical amplifiers for up and down sides inserted in an optical transmission link having up and down side optical fibre channels for a two way communication, characterised in that a pair of optical attenuators are arranged between said up and down side optical fibre channels and a pair of optical couplers for tapping and coupling, so as to attenuate up and down side trunk channel signals superimposed with a modulated supervisory signal, are connected to said up and down side optical fibre channels, thereby returning up and down side returned signals inversely into said down and up side optical fibre channels so that said up and down side returned signals are superimposed with said down and up side trunk channel signals, respectively, by way of both of said up and down side optical fibre channels.

6. A supervising loopback circuit for an optical repeater system, provided in an optical repeater constituted of a pair of optical amplifiers for up and down sides inserted in an optical transmission link having up and down side optical fibre channels for a two way communication, characterised in that a pair of optical couplers are arranged in opposition with each other between said up and down side optical fibre channels so as to attenuate an optical signal passing therethrough and a pair of optical couplers for tapping and coupling up and down side trunk channel signals

superimposed with a modulated supervisory signal and backscatter light, so as to attenuate an optical signal passing therethrough are connected to said up and down side optical fibre channels, thereby returning up and down side returned signals and said backscatter light inversely into said down and up side optical fibre channels so that said up and down side returned signals and said backscatter light are superimposed with said down and up side trunk channel signals, respectively, by way of both of said up and down side optical fibre channels.

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UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4B(BK8,BK8B,BK8C,BK16,BK16D)

Int Cl (Ed.6): H04B

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB2236235A	STC	
A	GB2207827A	KOKUSAI DENSHIN DENWA KK	
A	GB2123236A	PHILIPS	
X,P	EP0531047A2	ATT - whole document	1,2,3,6
A	EP0084371A	SIEMENS	
A	US4736464A	BBC BROWN BOVERI & CO & EP0176015A	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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